PB-239 645

BADGER LAKE, POLK COUNTY, MINNESOTA

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center
Minnesota National Guard
Minnesota Pollution Control Agency

November 1974

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National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

REPORT
ON
BADGER LAKE
POLK COUNTY
MINNESOTA

EPA REGION V

WORKING PAPER No. 82

WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

NOVEMBER, 1974

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

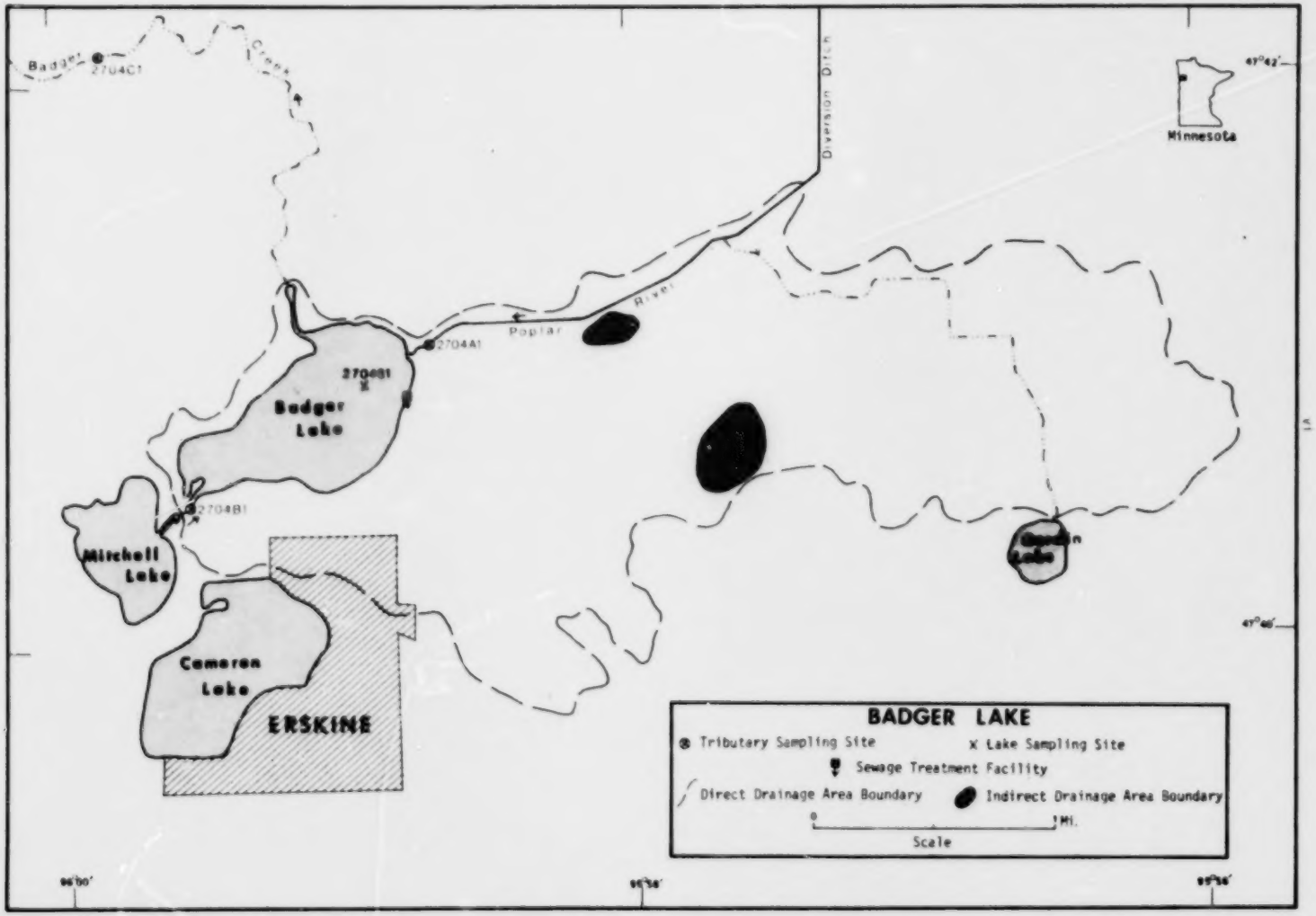
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


Badger Creek
2704C1
Diversion Ditch
Minnesota
47°42'
Poplar River
2704A1
270401
Badger Lake
2704B1
Mitchell Lake
Cameron Lake
ERSKINE
47°00'
BADGER LAKE
Tributary Sampling Site
X Lake Sampling Site
Sewage Treatment Facility
Direct Drainage Area Boundary
Indirect Drainage Area Boundary
0
1 Mi.
Scale
96°00'
95°54'
95°48'

BADGER LAKE

STORET NO. 2704

I. CONCLUSIONS

A. Trophic Condition:

Badger Lake is considered to be eutrophic. Although Survey limnologists did not observe any algal blooms, they did report heavy growths of rooted aquatic vegetation.

The Survey lake data indicate relatively good water quality; and, if these data were the only basis for judgement, this rather shallow lake might be considered mesotrophic. However, in a number of other shallow Survey study lakes where rooted aquatic vegetation was the primary manifestation of eutrophy (e.g., Shawano Lake, Wisconsin), nutrient levels were low, little chlorophyll a was detected, Secchi disc transparencies were good to excellent, and algal assay control yields (in response to low nutrient levels) were low.

Among the 60 Minnesota lakes sampled in the fall when essentially all were well-mixed, 10 had less mean total phosphorus, 15 had less mean dissolved phosphorus, and 15 had less mean inorganic nitrogen. For all 80 lakes sampled, 22% had greater Secchi disc transparency, but none had less mean chlorophyll a.

B. Rate-Limiting Nutrient:

Because of nutrient loss, the algal assay results are not considered reliable. However, the lake data indicate nitrogen

limitation in July and October and phosphorus limitation in September.

C. Nutrient Controllability:

1. Point sources--During the sampling year, it is calculated that Badger Lake received a total phosphorus load at a rate about 1½ times that proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 12). Of that load, it is estimated that the Village of Erskine contributed about 71%.

It is calculated that institution of 70% phosphorus removal at Erskine would reduce the loading rate to 0.32 g/m2/yr or less than Vollenweider's eutrophic rate. However, it is concluded that the rooted aquatic vegetation would continue to be a problem because of the alternate sediment source of nutrients and the shallowness of the lake.

2. Non-point sources (see page 12)--The phosphorus exports of the Badger Lake subdrainage compare well with those of other unimpacted streams studied elsewhere in western Minnesota (e.g., the mean P export of four streams tributary to Big Stone Lake was 19 lbs/mi^2/yr).

In all, non-point sources are estimated to have contributed less than 29% of the total phosphorus load during the sampling year.

III. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry*:

1. Surface area: 354 acres.
2. Mean depth: 4 feet.
3. Maximum depth: 11 feet.
4. Volume: 1,416 acre/feet.
5. Mean hydraulic retention time: 108 days.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area†	Mean flow†
Poplar River	28.9 mi^2	5.7 cfs
Mitchell Lake outlet	2.3 mi^2	0.4 cfs
Minor tributaries & immediate drainage -	2.5 mi^2	0.5 cfs
Totals	33.7 mi^2	6.6 cfs

2. Outlet -

Badger Creek	34.2 mi^{2}††	6.6 cfs

C. Precipitation†††:

1. Year of sampling: 24.8 inches.
2. Mean annual: 17.9 inches.

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* Anonymous, 1972.
† Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi^2.
†† Includes area of lake.
††† See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Badger Lake was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two depths at one station on the lake (see map, page vi). During each visit, a single depth-integrated (near bottom to surface) sample was collected for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was taken for algal assays. Also each time, a depth-integrated sample was collected for chlorophyll a analysis. The maximum depth sampled was 4 feet.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake was essentially well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (10/20/72)		
Temperature (Cent.)	2.1	2.1	2.1	2.1
Dissolved oxygen (mg/l)	12.2	12.2	12.2	12.2
Conductivity (μmhos)	460	460	460	460
pH (units)	8.4	8.4	8.4	8.5
Alkalinity (mg/l)	183	184	184	185
Total P (mg/l)	0.022	0.026	0.026	0.030
Dissolved P (mg/l)	0.015	0.018	0.018	0.021
NO_2 + NO_3 (mg/l)	0.040	0.045	0.045	0.050
Ammonia (mg/l)	0.070	0.075	0.075	0.080
		ALL VALUES		
Secchi disc (inches)	52	77	84	96

B. Biological characteristics:

1. Phytoplankton* -

Sampling Date	Dominant Genera	Number per ml
07/11/72	1. Dinobryon	1,713
	2. Microcystis	241
	3. Cryptomonas	229
	4. Anabaena	72
	5. Scenedesmus	48
	Other genera	194
	Total	2,497
10/20/72	1. Dinobryon	452
	2. Flagellates	434
	3. Cryptomonas	187
	4. Navicula	64
	5. Achnanthes	54
	Other genera	219
	Total	1,410

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
07/11/72	01	3.6
09/08/72	01	0.9
10/20/72	01	1.7

* The September phytoplankton sample was lost in shipment.

C. Limiting Nutrient Study:

A significant loss of nutrients occurred between sample collection and the beginning of the algal assay, and the results are not reliable.

The lake data indicate nitrogen limitation in July and October (N/P ratios were 9/1 and 7/1, respectively, and nitrogen limitation would be expected) but phosphorus limitation in September (N/P = 17/1).

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff months of April and May, when two samples were collected, and December when samples were omitted. Sampling was begun in October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings. Nutrient loadings for "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the nutrient loads, in lbs/mi^2/year, calculated for the Poplar River at station A-1 and multiplying those by the ZZ area in mi^2.

The Village of Erskine declined participation in the Survey, and nutrient loads there were estimated at 2.5 lbs P and 7.5 lbs N/capita/year.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Erskine	571*	Ponds	0.057**	Badger Lake

2. Known industrial - None

* Anonymous, 1973.
** Estimated at 100 gal/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Poplar River	430	21.5
Mitchell Lake outlet	40	2.0
b. Minor tributaries & immediate drainage (non-point load) -	40	2.0
c. Known municipal -		
Erskine	1,430	71.5
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	60	3.0
Total	2,000	100.0

2. Outputs -

Lake outlet - Badger Creek 2,090

3. Net annual P loss - 90 pounds

* See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
Poplar River	22,250	66.6
Mitchell Lake outlet	1,530	4.6
b. Minor tributaries & immediate drainage (non-point load) -	1,920	5.8
c. Known municipal -		
Erskine	4,280	12.8
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	3,410	10.2
Total	33,390	100.0

2. Outputs -

Lake outlet - Badger Creek 33,290

3. Net annual N accumulation - 100 pounds

* See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Poplar River	15	770
Mitchell Lake outlet	17	665

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vol eider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Units	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
lbs/acre/yr	5.6	loss*	94.3	0.3
grams/m^2/yr	0.63	-	10.6	0.03

Vollenweider loading rates for phosphorus (g/m^2/yr) based on mean depth and mean hydraulic retention time of Badger Lake:

"Dangerous" (eutrophic rate)	0.38
"Permissible" (oligotrophic rate)	0.19

* The apparent loss of 90 pounds of phosphorus during the sampling year is believed to be due to the location of the outlet sampling station some two stream miles below the actual outlet of the lake. Thus an additional drainage load was included as an output but not included in the inputs. Underestimation of the Erskine phosphorus contribution also would result in the apparent loss.

V. LITERATURE REVIEWED

Anonymous, 1972. Survey questionnaire. MPCA, Minneapolis.

Anonymous, 1973. Wastewater disposal facilities inventory. MPCA, Minneapolis.

Johnson, Clare L., 1952. Waterflow and muskrat habitat survey--Badger Lake, Polk County. MN Dept. of Conservation, St. Paul.

Schilling, Joel, 1974. Personal communication (lake map). MPCA, Minneapolis.

Vollenweider, Richard A., (in press). Input-output models. Schweiz. A. Hydrol.

LAKE CODE 2716 [illegible] LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27040I	10	72	[illegible]	15	2.20				
	11	72	1.47	12	1.80				
	12	72	1.83	10	1.90				
	1	73	0.45	21	0.40				
	2	73	0.41	4	0.30				
	3	73	10.70	14	6.40				
	4	73	3.62	[illegible]	1.40	22	5.70		
	5	73	2.02	13	3.90				
	6	73	1.73	3	2.60				
	7	73	1.30	5	1.50				
	8	73	6.34	21	24.00				
	9	73	32.50	15	20.00				
27C477	10	72	0.14	15	0.20				
	11	72	0.08	12	0.10				
	12	72	0.12	10	0.10				
	1	73	1.10	21	0.02				
	2	73	1.17	4	0.02				
	3	73	2.73	14	1.50				
	4	73	0.27	5	0.10	22	0.50		
	5	73	0.17	13	0.30				
	6	73	0.15	3	0.20				
	7	73	0.12	4	0.10				
	8	73	0.43	21	0.37				
	9	73	2.15	15	2.00				

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VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 2704 HAINES LAKE

TOTAL DRAINAGE AREA OF LAKE 34.20

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
27044I	28.90	3.42	0.27	3.68	21.60	13.50	12.10	6.14	2.62	4.11	1.93	1.31	1.11	5.74
27044I	2.10	0.33	0.01	0.14	1.50	1.03	0.99	0.48	0.17	0.35	0.13	0.07	0.06	0.42
2704C1	34.20	0.42	0.29	3.91	25.80	16.00	14.40	7.30	3.09	4.79	2.27	1.56	1.22	6.75
270477	3.01	0.32	0.02	0.24	1.97	1.32	1.10	0.62	0.21	0.46	0.17	0.09	0.08	0.54

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 34.20
SUM OF SUB-DRAINAGE AREAS = 34.21
TOTAL FLOW IN = 80.34
TOTAL FLOW OUT = 81.05

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27044I	10	72	1.77	15	2.30				
	11	72	1.23	12	1.50				
	12	72	1.57	10	1.60				
	1	73	0.45	21	0.40				
	2	73	0.29	4	0.30				
	3	73	10.05	14	24.00				
	4	73	3.22	4	1.20	22	5.60		
	5	73	1.76	13	3.30				
	6	73	1.45	3	2.60				
	7	73	1.17	8	1.40				
	8	73	44.30	21	38.00				
	9	73	28.10	16	17.00				
27044I	10	72	0.13	15	0.20				
	11	72	0.07	12	0.08				
	12	72	0.09	10	0.09				
	1	73	0.02	21	0.02				
	2	73	0.01	4	0.01				
	3	73	0.60	14	1.20				
	4	73	0.21	4	0.08	22	0.40		
	5	73	0.13	13	0.20				
	6	73	0.12	3	0.20				
	7	73	0.09	8	0.10				
	8	73	0.35	21	4.50				
	9	73	2.40	16	1.50				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 72/10/30

Reproduced from best available copy.

270401
47 40 55.0 096 00 28.0
BADGER LAKE
27 MINNESOTA

11EPALES 2111202
3 0005 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/11	12 10 0000				52	450	8.80	157	0.040	0.090	0.026	0.014
	12 10 0003		24.2	11.2		459	8.80	162	0.040	0.060	0.022	0.012
72/09/08	10 15 0000				84		8.60	155	0.060	0.140	0.016	0.012
	10 15 0004		15.2	10.4		485	8.70	153	0.060	0.120	0.015	0.010
72/10/20	14 45 0000				96	460	8.40	185	0.050	0.080	0.022	0.015
	14 45 0004		2.1	12.2		460	8.50	183	0.040	0.070	0.030	0.021

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/07/11	12 10 0003		3.7J
72/09/08	10 15 0000		0.3J
72/10/20	14 45 0000		1.7J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY DATA

STORET RETRIEVAL DATE 74/10/30

2704A1 LS2704A1
47 41 00.0 096 00 00.0
POPLAR RIVER DITCH - BADGER LAKE
27 7.5 ERSKINE
1/BADGER LAKE
US 59 XING 1 MI N OF ERSKINE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	10 00		0.076	1.250	0.084	0.011	0.025
72/11/12	10 30		0.023	0.960	0.069	0.013	0.013
73/01/21	09 00		0.063	1.990	0.084	0.005K	0.045
73/02/04	09 30		0.110	0.780	0.046	0.006	0.025
73/03/18	10 30		2.300	1.800	0.140	0.025	0.075
73/04/08	09 00		0.015	3.200	0.052	0.011	0.030
73/04/22	09 30		0.027	3.570	0.091	0.005K	0.030
73/05/13	09 35		0.012	2.700	0.039	0.019	0.045
73/05/20	09 40		0.028	1.380	0.016	0.010	0.035
73/06/03	13 00		0.010K	1.950	0.009	0.037	0.055
73/07/08	10 00		0.021	2.260	0.154	0.042	0.070
73/08/21	07 30		0.010K	1.100	0.120	0.011	0.042
73/09/16	09 00		0.010K	2.150	0.160	0.016	0.035

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

2704M1 LS2704M1
47 40 30.0 09A 01 30.0
MITCHELL LK/BADGER LK CONN
27 7.5 ERSKINE
T/BADGER LAKE
US 2 ABOG 4W OF ERSKINE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/11/12	10 00		0.025	1.340	0.105	0.009	0.019
73/01/21	09 30		0.370	2.100	0.086	0.005K	0.045
73/02/04	10 00		0.430	1.730	0.095	0.014	0.160
73/03/18	10 00		0.420	1.680	0.450	0.115	0.135
73/04/08	10 00		0.019	3.900	0.050	0.005K	0.025
73/04/22	10 00		0.010K	1.380	0.012	0.006	0.025
73/05/13	10 00		0.010K	1.350	0.020	0.006	0.025
73/05/20	10 00		0.010K	2.100	0.033	0.006	0.020
73/06/03	09 00		0.034	1.150	0.011	0.005K	0.025
73/07/08	10 30		0.020	3.700	0.087	0.017	0.040
73/08/21	08 00		0.064	1.390	0.138	0.012	0.025
73/09/16	10 00		0.010K	1.680	0.115	0.021	0.040

K- VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

2704C1 LS2704C1
47 42 00.0 046 02 00.0
HADGER CREEK
27 7.5 ERSKINE
O/HADGER LAKE
SECONDARY RD KING 2.5 MI NNW OF ERSKINE
11CPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	10	30	0.110	2.200	0.210	0.046	0.115
72/11/12	09	30	0.017	1.515	0.084	0.035	0.052
73/01/21	10	30	0.050	3.500	0.100	0.073	0.410
73/02/04	10	30	0.300	2.800	0.140	0.054	0.240
73/03/18	09	30	0.520	1.500	0.105	0.014	0.065
73/04/08	10	30	0.010K	2.310	0.030	0.007	0.022
73/04/22	10	30	0.010K	1.700	0.032	0.008	0.024
73/05/13	10	30	0.010K	1.470	0.012	0.022	0.055
73/05/20	10	30	0.012	3.100	0.036	0.022	0.050
73/06/03	09	00	0.770	1.800	0.044	0.005K	0.155
73/07/04	09	30	0.020	3.900	0.115	0.075	0.142
73/08/21	07	45	0.010K	3.000	0.132	0.270	0.380
73/09/16	10	30	0.010K	5.100	0.138	0.378	0.430

K VALUE KNOWN TO BE LESS
THAN INDICATED

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1. REPORT NO.	2.	3. PB 239 645
4. TITLE AND SUBTITLE: Report on Badger Lake, Polk County, Minnesota		5. REPORT DATE: Prepared November 1974
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S): Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO.: Working Paper # 82
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Pacific Northwest Environmental Research Laboratory U.S.Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO.: 1BA029 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS: U.S. Environmental Protection Agency		13. TYPE OF REPORT AND PERIOD COVERED: Final - 1972 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

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U S Department of Commerce
Springfield VA 22151

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18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Release unlimited		31
	20. SECURITY CLASS (This page)	22. PRICE $3.75

EPA Form 2220-1 (9-73)